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Parasites of Summer Flounder, *Paralichthys dentatus*, in the Chesapeake Bay

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ABSTRACT: A total of 38 species of parasites was collected from 341 summer flounder, *Paralichthys dentatus*, in the Chesapeake Bay. The parasites included 8 species of protozoans, 1 monogenean, 11 digeneans, 2 acanthocephalans, 1 copepod, 1 branchiuran, 1 leech, 10 cestodes, and 4 nematodes. Of the 38 parasites, only 18 species were found in more than 10% of the hosts. Protozoans included the flagellates *Cryptobia* sp. from the gills and *Trypanoplasma bullocki* from the blood, the myxozoan *Davisia branchiophora* from the gall bladder and the ciliate *Trichodina* sp. from the gills. The monogenean *Neoheterobothrium affine* occurred on the gills, and digeneans included *Stephanostomum dentatum* and *Opecoeloides vitellosus* from the intestine and *Stephanostomum tenue* encysted in the gills. The acanthocephalan *Serrasentis sagittifer* was encapsulated in the mesentery. Metacestodes included *Nybelinia bisulcata* encapsulated in the intestinal wall, *Grillotia smarisgora* encapsulated in the mesentary, *Rhinobothrium* sp. in the intestine, and 3 different forms of the group *Scolex pleuronectis*, 1 in the intestine, 1 in the gall bladder, and 1 encapsulated in the gills. Other abundant parasites included the nematodes *Dichelyne cylindricus* in the intestine and a juvenile *Hysterothylacium* sp. encapsulated in the mesentery, and the branchiuran *Argulus chesapeakensis* on the skin. Parasite abundance was analyzed with respect to host size, season, and host migration into and out of Chesapeake Bay. Some parasites, such as *Bucephalopsis paralichthydis* and *A. chesapeakensis*, were clearly acquired in the Bay during summer, whereas *Bothriocephalus scorpii*, *Hysterothylacium habena*, *Acanthochondria galerita*, and *Rhinobothrium* sp. appeared to be acquired offshore. *Cryptobia* sp. and *T. bullocki* were more prevalent in fish less than 300 mm total length (TL), whereas *S. dentatum*, the various *S. pleuronectis* types, *Rhinobothrium* sp., *D. cylindricus*, and the encysted species were more prevalent in fish greater than 300 mm TL.

KEY WORDS: *Paralichthys dentatus*, parasites, Chesapeake Bay, seasonality, Protozoa, Monogenea, Digenea, Cestoda, Nematoda, Acanthocephala, Branchiura, Copepoda, Hirudinea.

The summer flounder, *Paralichthys dentatus* (L.), is an important commercial and recreational species along the middle Atlantic coast of the United States. The species ranges from Nova Scotia to Florida (Guntherz, 1967) but it is most abundant between Cape Cod, Massachusetts, and Cape Fear, North Carolina. Adult summer flounder normally inhabit coastal and estuarine waters during the warmer months and remain offshore in 36–182 m of water during the fall and winter (Bigelow and Schroeder, 1953; Rogers and Van Den Avyle, 1983). Mature individuals migrate out of Chesapeake Bay in October and spawning takes place on the bottom as fish migrate to their overwintering grounds on the continental shelf (Morse, 1981). Eggs and larvae rise and drift inshore to coastal and estuarine nursery areas (Smith, 1973). Juvenile flounder remain in nursery areas until October of their second year of life (Powell and Schwartz, 1977). At that time, at least in Chesapeake Bay, a portion of these juveniles migrates out of the estuary and overwinters in nearshore waters along the coasts of Virginia and North Carolina. In April each year fish return to shallow coastal waters and estuaries (Hildebrand and Schroeder, 1928).

The food habits of summer flounder have not been extensively studied. The investigations that have been conducted suggest that fish less than 300 mm total length feed predominantly on crustacea and small fish, whereas larger flounder consume higher percentages of large fish and squid (Smith and Daiber, 1977; Powell and Schwartz, 1979; Langton and Bowman, 1981).

The parasite fauna of summer flounder is not well known. There has been no thorough survey of summer flounder parasites, but summer flounder were included in fish parasite surveys conducted by Linton (1889, 1897, 1898, 1900, 1901, 1905, 1940) from fish collected at Woods Hole, Massachusetts, and Beaufort, North Carolina, by Davis (1917) and Manter (1931) at Beaufort, and by Meyers (1978) from frozen samples originally collected in Raritan Bay, New Jersey. It is not clear if the flounder studied by Linton (1905) from North Carolina were summer flounder or the closely related southern flounder, *Paralich-*

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thys lethostigma Jordan and Gilbert. Various parasites of summer flounder have been reported in other studies, including myxozoa by Walford (1958), hematozoa by Laird and Bullock (1969), Burreson and Zwerner (1982), and Khan and Newman (1982), gill flagellates by Burreson and Sypek (1981), nematodes by Cheng (1976), branchiurans by Cressey (1978), leeches by Burreson and Zwerner (1982), and a digenean by Hunninen and Cable (1941).

The purpose of this study was to survey the parasites of summer flounder collected from the Chesapeake Bay region and to attempt to relate parasite fauna to host size and migratory patterns.

Materials and Methods

Summer flounder were collected monthly from the lower York River and lower Chesapeake Bay, Virginia, by otter trawl between April 1980 and October 1982. Overwintering juveniles were also collected 1.5 km off Virginia Beach, Virginia, from October through March. Samples of migrating flounder returning to the Bay were collected near the mouth of Chesapeake Bay during April and May each year, and samples of flounder leaving the Bay were collected there during September and October. Based upon published feeding and migratory habits, hosts were divided into 2 groups designated juveniles (<300 mm) and adults (>300 mm).

Live flounder were brought to the laboratory, held in flowing seawater tanks, and examined for parasites within 5 days of capture. One drop of blood from the caudal vessels was mixed with a drop of 0.6% saline and examined at 100× for the presence of flagellates. Permanent blood smears were stained in Giemsa and scanned for protozoa at 400×. The external surfaces were examined for parasites with the unaided eye. Individual gill arches were placed in sea water and examined with a dissecting microscope. Filaments from 1 arch were scraped onto a glass slide and examined at 400× for protozoa. Permanent smears were treated as above for blood smears. The liver, spleen, gonads, musculature, and internal and external surfaces of the gastrointestinal tract were examined with a dissecting microscope. Bile and urine were examined at 400×; permanent smears were treated as blood smears. Protozoa were enumerated on a subjective scale from 1 to 4 representing light to heavy infections. Helminths, excluding nematodes, were relaxed in distilled H_2O and fixed in AFA; crustaceans were fixed unrelaxed in AFA; and nematodes were fixed unrelaxed in glacial acetic acid. Specimens were stored in 70% ethanol. Most helminths were stained in Semichon's acetocarmine, cleared in methyl salicylate, and mounted in permount. Crustaceans were stained with picric acid fuchsin and mounted in Hoyer's medium ringed with Zut. The terms prevalence, mean intensity, and abundance follow the definitions of Margolis et al. (1982).

Gill filaments with encysted parasites and portions of operculum with embedded monogeneans were fixed in 10% buffered formalin, decalcified in HCl, embedded in paraffin, sectioned at 5 μm, and stained with hematoxylin and eosin.

Differences in parasite prevalence and mean intensity among season, sex, size, and migrating fish were tested using 2 × 2 contingency tables and Chi-square analyses. The Yates correction for continuity was applied when expected frequencies were small. Values were calculated only for those parasites that occurred in at least 10% of the hosts. All statistical tests of significance were made with alpha = 0.05.

Results and Discussion

A total of 341 summer flounder was examined for parasites; 260 juveniles (<300 mm) and 81 adults (>300 mm) were collected. Twenty-three adults were collected as they returned to the Bay in the spring, 37 adults were collected during summer in the Bay, and 21 adults were collected as they migrated out of the Bay in the fall.

A total of 38 species of parasites was collected (Table 1); 20 of these, indicated by asterisks, are new host records. Twenty of the species were found in fewer than 10% of the hosts and most of these species will not be considered further in this report. There was no difference in prevalence and intensity between male and female fish for any parasite.

Morphology of *Davisia brachiophora* differed from that of the original description (Davis, 1917). Spore appendages varied greatly in length from 10 to 100 μm as opposed to 18–22 μm in the original description. In addition, many spores had long threadlike filaments, up to 100 μm long, projecting from the ends of the appendages. These filaments were not mentioned in the original description, but figure 113 (Davis, 1917) shows a short projection from one of the appendages that may be a broken filament. *Davisia longibrachia* Kabata also has threadlike lateral appendages, but this species has gradually tapering appendages (Kabata, 1962), whereas *D. brachiophora* has blunt appendages.

Stephanostomum dentatum was the most abundant digenean and more data were collected for this species (Table 2) than for others. Preserved individuals ranged in length from 0.3 to 4.1 mm. The smallest worm observed with eggs was 0.9 mm long. During spring, most individuals were small and immature; mean size and egg production increased through summer and fall, although new infections continued to be acquired. Egg production and acquisition of worms ceased during winter, and most, if not all, of the worms were lost.

All cestodes collected were plerocercoids ex-

Table 1. Parasites of summer flounder ($N = 341$) in the Chesapeake Bay.

Parasite	Location	Peak abundance	Prevalence %	USNM No.
Sarcomastigophora				
Amyloodinium sp.*	G	S	2.9	
Cryptobia sp.	G	S	38.7	
Trypanoplasma bullocki (Strout, 1965)	B	W	26.7	80707
Ichthyobodo sp.*	G	S	0.9	
Hexamita sp.*	GB	S	1.2	
Apicomplexa				
Haemogregarina platessae Lebailly, 1904	B	YR	5.9	80708
Myxozoa				
Davisia branchiophora (Davis, 1917)*	UB	YR	17.6	
Ciliophora				
Trichodina sp.*	G	S	17.0	
Monogenea				
Neoheterobothrium affine (Linton, 1898)	G, M	S	11.4	80709
Digenea				
Bucephalopsis paralichthydis (Corkum, 1961)*	RM	S	6.7	80710
Stephanostomum dentatum (Linton, 1900)	I	S	37.5	80711
Stephanostomum tenue (Linton, 1898)*	G (E)	S	10.0	80712
Lepocreadium setiferoides (Miller and Northup, 1926)	I	R	0.3	80713
Lepocreadium areolatum (Linton, 1900)*	I	R	0.6	80714
Opecoeloides fimbriatus (Linton, 1934)*	I	R	0.6	80715
Opecoeloides vitellosus (Linton, 1900)	I	S	13.5	80716
Parahemiurus merus (Linton, 1910)*	ST	R	1.5	80717
Lecithochirium synodi Manter, 1931	ST	R	1.2	80718
Hirudinella ventricosa (Pallas, 1774)*	ST	R	0.3	80719
Microphallus turgidus (Leigh, 1958)*	ST	R	0.3	80720
Acanthocephala				
Serrasentis sagittifer (Linton, 1889)	I, MS (E)	YR	10.0	80721
Dollfusentis chandleri Golvan, 1969*	I	R	0.9	80722
Cestoda				
Nybelinia bisulcata (Linton, 1889)	I (E)	S	10.9	80723
Grillotia smarisgora (Wagener, 1854)*	MS (E)	S	19.6	80724
Bothriocephalus scorpii (Mueller, 1776)	I	S	4.4	80725
Scolex pleuronectis type A	I	S	50.7	80726
Scolex pleuronectis type B	I	W	6.5	80727
Scolex pleuronectis type C	GB	S	34.6	80728
Scolex pleuronectis type D*	G (E)	S	12.0	
Ceratobothrium xanthocephalum Monticelli, 1892*	I	YR	7.9	80729
Rhinobothrium sp.*	I	S	10.0	80730
Nematoda				
Dichelyne cylindricus Chandler, 1935	I	S	13.5	80731
Capillaria sp.*	I	S	4.7	80732
Hysterothylacium habena (Linton, 1900)*	I	S	5.0	80733
Hysterothylacium type A*	MS (E)	YR	27.6	80734
Hirudinea				
Calliobdella vivida (Verrill, 1872)	SK	W	1.2	80735
Branchiura				
Argulus chesapeakensis Cressey, 1971	SK	S	12.9	80736
Copepoda				
Acanthochondria galerita (Rathbun, 1886)	MS	S	4.7	

* = New host record, B = blood, (E) = encysted, G = gills, GB = gall bladder, I = intestine, M = mouth, MS = mesentery, R = rare, RM = rectum, S = summer, SK = skin, ST = stomach, UB = urinary bladder, W = winter, YR = year-round.

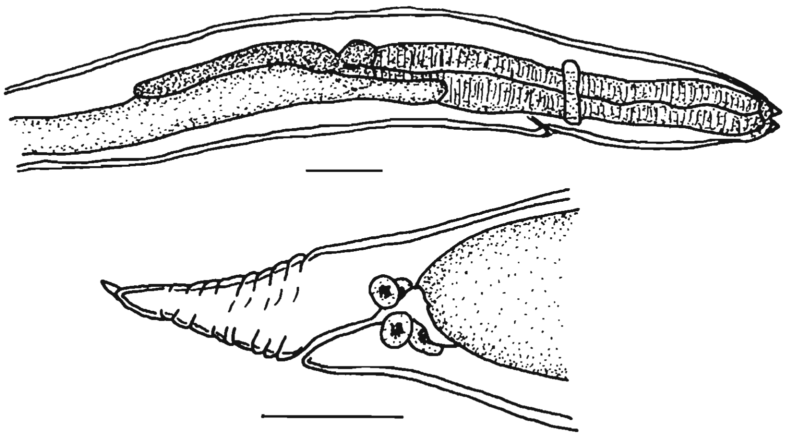

Figure 1. Anterior and posterior extremities of *Hysterothylacium* type A. Scale bars = 1.0 mm.

cept *Bothriocephalus scorpii. Scolex pleuronectis* encompasses a wide variety of metacestodes having 4 bothridia and an apical sucker. Four different types were determined based on morphology and location in the host (Table 1). Types A, B, and C appear identical to *Echeneibothria* sp. from summer flounder illustrated by Linton (1897) in plate LXI, figures 4, 10, and 12, respectively. It is not known if these types represent separate species or only different developmental stages of the same species. Type D was distinguished by its location embedded in host gills.

The juvenile nematode *Hysterothylacium* type A has a body 11–22 mm long by 0.2–0.4 wide; cuticular alae lacking; cuticle with inconspicuous annules becoming prominent on tail; single boring tooth; esophagus 2.3–4.3 mm long, 19.5–21.9% of body length; ventriculus 0.40–0.43 mm long; ventricular appendage 5.4–8.0 mm long; intestinal cecum 2.8–3.5 mm long; ratio of cecal to ventricular appendage 1:1.9–2.3; nerve ring in anterior 28–39% of esophagus, 0.15–0.22 mm in breadth; tail with single spine at tip (Fig. 1). This nematode is similar to *Hysterothylacium* type HA of Deardorff et al. (1982), except that it has a longer esophagus and cecal appendage and the tail has marked caudal annulations. *Hysterothylacium* type A also resembles *Hysterothylacium* type MD of Deardorff and Overstreet (1981) except that type A is longer, the nerve ring is more anterior, and the excretory port opens caudad to the nerve ring. Type A also has a smaller cecal to ventricular appendage length ratio and has marked cuticular annulations on the tail.

Seasonality

The seasonal variation in parasitism in summer flounder is shown in Table 3 and, for young-of-the-year fish, in Table 4. The data from Table 4 are also included in Table 3. Seasonality was similar in the York River and at the lower Bay station, reflecting the widespread distribution of the host as well as similar environmental conditions between the 2 areas. Only *Cryptobia* sp. was more prevalent in the York River. Most parasites, even the encapsulated cestodes, were more

Table 2. Seasonal changes in egg production, maturity, size, prevalence, and intensity of *Stephanostomum dentatum* in summer flounder from the Chesapeake Bay.

	Sample month			
	Apr–Jun	Jul–Sep	Oct–Nov	Dec–Mar
No. worms sampled	123	151	101	25
Percent mature	10.6	54.4	91.1	100.0
Mean number of eggs	5.1	13.0	26.6	0.0
Mean worm length (mm) ± SD	0.75 ± 0.25	1.00 ± 0.65	2.08 ± 2.00	1.11 ± 0.15
Prevalence (%)	35.6	56.3	46.3	9.8
Mean intensity	11.6	14.4	14.7	2.6
No. hosts sampled	105	119	41	76

Table 3. Seasonal prevalence (P%) and mean intensity (I) of parasites of summer flounder in the Chesapeake Bay.

	Apr–Jun				Jul–Oct				Nov–Mar			
	P		I		P		I		P		I	
Parasite	J (70)*	A (35)	J	A	J (100)	A (46)	J	A	J (90)	A (0)	J	A
Cryptobia sp.	58.6	25.7	2.8	2.6	60.0	19.6	2.0	1.4	21.1	–	2.4	–
Trypanoplasma bullocki	18.6	0.0	2.1	0.0	2.0	0.0	1.0	0.0	80.0	–	2.5	–
Trichodina sp.	14.3	28.6	1.9	1.9	23.0	19.6	1.5	1.6	6.7	–	2.0	–
Neoheterobothrium affine	20.0	14.3	1.4	1.6	3.0	4.3	1.0	1.0	16.7	–	1.2	–
Opecoeloides vitellosus	14.3	25.7	6.0	2.1	24.0	4.3	1.0	1.0	8.9	–	2.9	–
Stephanostomum dentatum	21.4	62.9	15.3	7.7	46.0	76.0	7.0	25.1	10.0	–	2.6	–
Stephanostomum tenue	12.9	37.1	18.3	17.3	3.0	15.2	5.0	132.0	0.0	–	0.0	–
Serrasentis sagittifer	1.4	40.0	4.0	2.7	1.0	34.8	3.0	4.1	2.2	–	1.0	–
Nybelinia bisulcata	15.7	28.6	7.5	10.3	6.0	13.0	10.0	12.7	4.4	–	5.3	–
Grillotia smarisgora	10.0	57.1	8.1	5.2	13.0	2.2	9.2	9.6	3.3	–	3.0	–
Scolex pleuronectis type A	54.3	94.3	27.0	55.1	43.0	43.5	27.5	40.4	43.3	–	9.0	–
Scolex pleuronectis type C	15.7	60.0	23.6	49.9	44.0	82.6	27.5	24.8	4.4	–	11.5	–
Scolex pleuronectis type D	4.3	37.1	44.7	78.9	1.0	47.8	1.0	262.1	0.0	–	0.0	–
Ceratobothrium xanthocephalum	5.7	17.1	9.0	33.3	5.0	6.5	23.8	14.7	0.0	–	0.0	–
Rhinobothrium sp.	15.7	57.1	7.1	6.9	2.0	0.0	1.8	0.0	2.2	–	1.5	–
Dichelyne cylindricus	4.3	20.0	2.0	5.9	11.0	52.2	1.8	2.2	2.2	–	1.5	–
Hysterothylacium sp. type A	12.9	37.1	9.8	5.5	32.0	28.3	3.8	9.2	28.9	–	4.5	–
Argulus chesapeakensis	2.9	0.0	1.0	0.0	30.0	26.1	3.3	3.8	0.0	–	0.0	–

* J = fish <300 mm (juveniles), A = fish >300 mm (adults); sample size shown in parentheses. No adult flounder occur in the Bay during winter.

prevalent during spring and summer; however, there was no seasonality in the abundance of the encapsulated acanthocephalan *Serrasentis sagittifer,* and the hemoflagellate *Trypanoplasma bullocki* was most abundant during winter. *Trypanoplasma bullocki* is known to be transmitted by the leech *Calliobdella vivida,* which is only present during winter (Burreson and Zwerner, 1982). This accounts for the peak prevalence of *T. bullocki* in juveniles during winter. Adult flounder are not present in the estuary during winter and, thus, are never exposed to *T. bullocki.* In addition, as the water temperature increases in late spring, flounder are able to eliminate the parasite (Burreson and Frizzell, 1986). *Neoheterobothrium affine* was not recovered from any flounder from September through November. Immature worms with developing opisthaptor clamps were found on gills from December through March. After all 4 pairs of clamps had developed, worms migrated to the oral cavity and matured while partially embedded in the oral mucosa and musculature. No *Rhinobothrium* sp. plerocercoids were found after June in fish from the Bay. The infected juvenile fish (Table 3) were all collected in nearshore waters off Virginia Beach from October through March. Seasonality was not as pronounced in the parasite fauna of young-of-the-year fish (Table 4) except for the blood protozoans *T. bullocki* and *Haemogregarina platessae.* Lack of seasonality in the other parasites may be because young-of-the-year fish have lived only in the estuarine system.

Effect of host size

The size (age) of a host can influence the parasite fauna through changes in diet, habitat, or immune competency. Parasites of 2 size groups of summer flounder are listed in Table 3; in addition, parasites of young-of-the-year fish are listed in Table 4. *Cryptobia* sp. and *T. bullocki* were more prevalent in smaller fish, reflecting habitat and, at least for *T. bullocki,* immune competence of the host. *Stephanostomum dentatum, Stephanostomum tenue, Nybelinia bisulcata, S. pleuronectis* types A, C, and D, *Rhinobothrium* sp., *Dichelyne cylindricus,* and *S. sagittifer* were more prevalent in large fish. Higher prevalence in large fish may result from an increasing occurrence of fish in the diet of larger hosts (Powell and Schwartz, 1979) and, for the larval forms, increased time for accumulation of worms. For example, known second intermediate hosts (Stunkard, 1961) for *S. dentatum* are

Table 4. Seasonal prevalence and mean intensity of parasites from young-of-the-year (<180 mm) summer flounder in the Chesapeake Bay.

Parasite	Oct–Mar $N = 62$		Apr–Sep $N = 52$	
	Prevalence	Intensity	Prevalence	Intensity
Cryptobia sp.	21.0	2.8	61.5	2.5
Trypanoplasma bullocki	66.1	2.4	1.9	1.0
Haemogregarina platessae	11.3	1.2	0.0	0.0
Davisia branchiophora	12.9	2.4	13.5	1.8
Trichodina sp.	9.7	2.0	15.4	1.7
Neoheterobothrium affine	22.6	1.1	7.7	1.0
Bucephalopsis paralichthydis	6.5	76.5	5.8	9.0
Opecoeloides vitellosus	6.5	3.5	11.5	3.0
Stephanostomum dentatum	11.3	4.0	13.5	3.6
Scolex pleuronectis type C	35.5	5.7	11.5	3.0
Hysterothylacium type A	27.4	4.5	9.6	2.6

the teleosts *Fundulus heteroclitus* and *Menidia menidia,* both common inhabitants of Chesapeake Bay. Larger flounder may feed more readily on these fishes and, thus, have a higher prevalence and intensity of *S. dentatum* (Table 3). The abundance of *Opecoeloides vitellosus,* on the other hand, appeared to be independent of host size. Metacercariae of this digenean encyst in the hemocoels of some marine amphipods. Relatively high prevalence of this worm in large flounder during spring indicates that these fish are feeding on amphipods.

Table 5. Prevalence (%) of parasites in adult summer flounder (>300 mm) migrating into Chesapeake Bay from offshore (Apr–May), within Chesapeake Bay (Jun–Aug), and migrating out of Chesapeake Bay (Sep–Oct).

Parasite	Apr–May $N = 23$	Jun–Aug $N = 37$	Sep–Oct $N = 21$
Cryptobia sp.	30.4	21.6	14.3
Trichodina sp.	39.1	16.2	19.0
Neoheterobothrium affine	13.0	10.8	0.0
Bucephalopsis paralichthydis	0.0	10.8	14.3
Opecoeloides vitellosus	30.4	5.4	9.5
Stephanostomum dentatum	73.9	62.2	81.0
Stephanostomum tenue	39.8	21.6	19.0
Serrasentis sagittifer	56.5	8.1	66.7
Nybelinia bisulcata	39.1	13.5	9.5
Grillotia smarisgora	73.9	40.5	57.1
Bothriocephalus scorpii	26.1	0.0	0.0
Scolex pleuronectis type A	47.8	83.8	81.0
S. pleuronectis type B	8.7	2.7	0.0
S. pleuronectis type C	91.3	59.5	47.6
S. pleuronectis type D	30.4	37.8	66.7
Rhinobothrium sp.	60.9	51.4	0.0
Ceratobothrium xanthocephalum	17.4	10.8	4.8
Dichelyne cylindricus	17.4	51.4	38.1
Hysterothylacium habena	30.4	0.0	0.0
Hysterothylacium type A	47.8	29.7	19.0
Argulus chesapeakensis	0.0	16.2	28.6
Acanthochondria galerita	17.4	16.2	0.0

Effect of host migration

The prevalence of parasites in adult flounder migrating into and out of Chesapeake Bay, as well as of those residing in the Bay during summer, is shown in Table 5. No definite conclusions can be reached about offshore or estuarine origin of parasites whose prevalence was relatively constant in all 3 groups of fish, e.g., *S. dentatum* or *S. pleuronectis* type A. Parasites with such even distributions may be acquired both offshore and in the Bay, or they may be long-lived parasites acquired in only one, or both, areas. Two parasites, *Bucephalopsis paralichthydis* and *Argulus chesapeakensis,* were clearly acquired in the Bay based upon their absence in April and May samples (incoming hosts) and their presence in summer (Bay) and fall (departing hosts) samples. Those parasites present in April/May and summer samples, but absent in fall samples, appear to be acquired offshore. Older flounder migrate into the Bay already parasitized with these species and gradually lose the parasites during summer without reacquisition. Thus, they are no longer parasitized by these species when they migrate out of the Bay during fall. Parasites such as *Rhinobothrium* sp., *B. scorpii,* and *H. habena* are lost quickly, whereas others, such as *Acanthochondria galerita,* are lost more slowly (Table 5). However, absence in fall samples does not necessarily mean the parasite is acquired only offshore. For example, *N. affine* is absent in fall samples but is present in young-of-the-year fish,

which have never migrated out of the Bay. This parasite appears to have an annual cycle with death of all worms by August. Thus, absence of this parasite in the fall is a function of the timing of its life cycle and not its area of acquisition.

Host specificity

Four groups of parasites can be identified based on their affinity for summer flounder. The first group consists of parasites found only in summer flounder; the nematode *D. cylindricus* is the only parasite in this group. The second group is found in association with summer flounder or closely related pleuronectiform fishes. Parasites include *D. branchiophora, B. paralichthydis, A. galerita,* and *N. affine.* The third group consists of parasites with little host specificity that can be recovered from a wide variety of unrelated fish species. Included are *Cryptobia* sp., *Trichodina* sp., *T. bullocki, S. dentatum, S. tenue, O. vitellosus, Ceratobothrium xanthocephalum, Rhinobothrium* sp., *S. pleuronectis, N. bisulcata, Grillotia smarisgora, C. vivida, A. chesapeakensis, S. sagittifer,* and *H. habena.* These parasites infect a large number of hosts that reflect functional similarities such as diet or habitat. The fourth group of parasites consists of the rare species with prevalences below 10% in Table 1. *Hirudinella ventricosa* and *Microphallus turgidus* are accidental parasites incapable of maturing in summer flounder. Oceanic fishes (Gibson and Bray, 1977) and aquatic birds (Heard and Overstreet, 1983), respectively, are the definitive hosts for these parasites. This pattern is similar to that of other northern fishes that are often infected with a large component of nonspecific enteric metazoan parasites and a smaller component of parasites that are more or less restricted to 1 host or host family (Appy and Burt, 1982; Bray, 1987).

Latitudinal gradients

It is difficult to draw conclusions on latitudinal gradients of summer flounder parasites because this study is the only thorough analysis involving a large number of parasites and hosts. For example, protozoa were not examined by Linton (1940) at Woods Hole or by Meyers (1978) in New Jersey, and, except for the blood protozoa (Laird and Bullock, 1969; Khan and Newman, (1982), this component of the fauna is unknown in the northern portion of the host range. However, even with limited collections at the extremes of the host range, it appears that most parasites prevalent in summer flounder in Virginia are widespread. The blood protozoans *T. bullocki* and *H. platessae* and the digenean *S. dentatum* are known from Massachusetts to North Carolina; the monogenean *N. affine,* the nematode *D. cylindricus,* and the copepod *A. galerita* are known from Massachusetts to Virginia, but probably occur in North Carolina. The digenean *O. vitellosus* is known from Massachusetts and Virginia, but was not reported by Meyers from New Jersey. However, other than the original description from *P. lethostigma* in Louisiana, the digenean *B. paralichthydis* is known only from Virginia. Many parasites of summer flounder reported by others, mainly from Woods Hole, New Jersey, and North Carolina, were not found in Virginia. In particular, fish from the northern portion of their range seemed to have a greater number and variety of juvenile nematodes.

Pathogenicity

Of the parasites listed in Table 1, only *T. bullocki* has been associated with mortality of feral summer flounder (Burreson and Zwerner, 1984). However, other listed parasites or related species are known pathogens in other fishes. These include *Amyloodinium* sp. (Paperna, 1980), *Ichthyobodo* sp. (Robertson et al., 1981; Cone and Wiles, 1984), *Haemogregarina sachai* (Kirmse, 1980), *Trichodina* sp. (Pearse, 1972), and *Argulus* sp. (Kolipinski, 1969; Kroger and Guthrie, 1972).

Although not implicated in mortality, some other parasites were associated with varying degrees of pathology. *Neoheterobothrium affine* elicited a chronic granulomatous inflammatory host response around the opisthaptor, which was embedded in the oral mucosa and musculature of the host. The response resulted in a fibrous tissue collar around the isthmus of the parasite. An inflammatory response was also elicited by *S. tenue* and *S. pleuronectis* type D embedded in the gills. Heavy infections of these 2 parasites were observed during this study and could interfere with gill function.

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